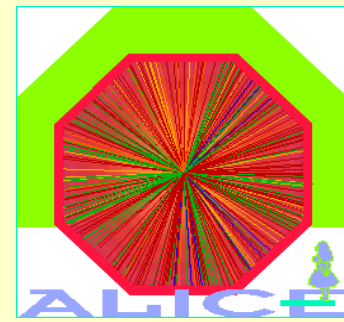
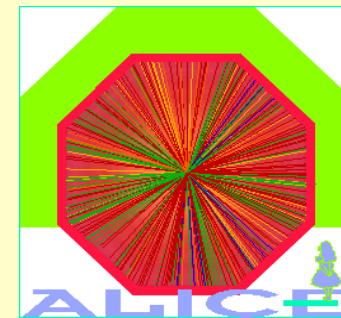


Central Meson Production in ALICE



- ALICE detector
- Selection of central diffractive single/double gap events
- Central Meson production in pp-collisions at $\sqrt{s} = 7$ TeV
- Analysis of $f_0(980)$ and $f_2(1270)$ production
- Central Meson production in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV
- Analysis of $\rho(770)$
- Conclusions, outlook

The ALICE experiment

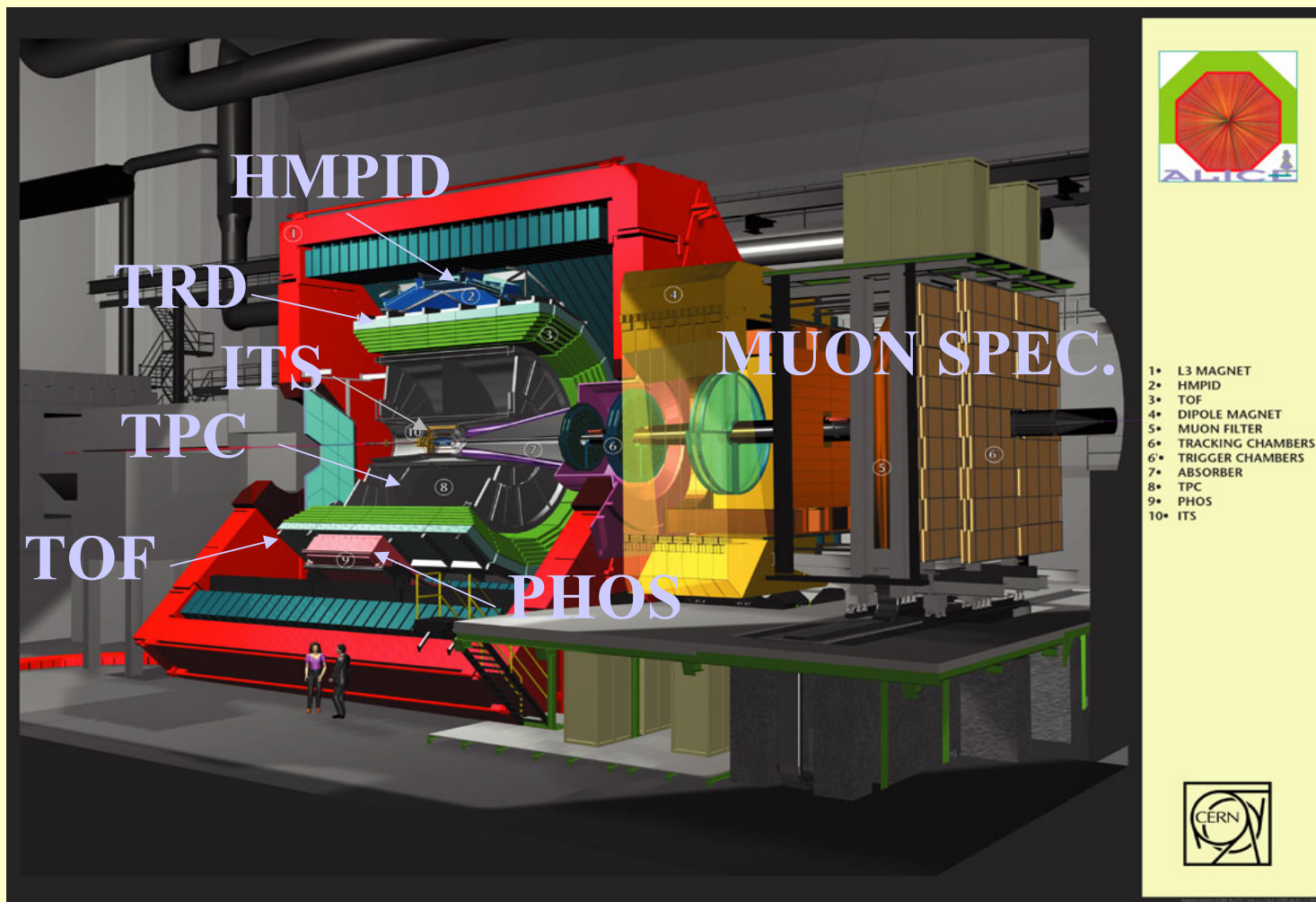


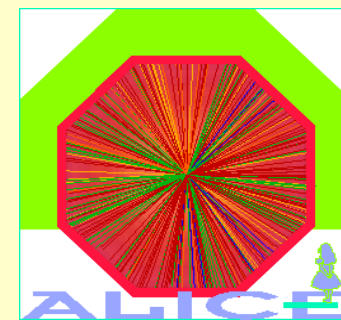
*Acceptance
central barrel*

$$-0.9 < \eta < 0.9$$

*Acceptance
muon spectr.*

$$-2.5 < \eta < -4.$$





ALICE pseudorapidity acceptance

→ *additional forward detectors*
(no particle identification)

$-3.7 < \eta < -0.9$ and $0.9 < \eta < 5.1$

→ *definition of gaps η_+ , η_-*

p-p luminosity $L = 5 \times 10^{30} \text{cm}^{-2}\text{s}^{-1}$:

→ reduced prob. overlapping events

diffractive L0 trigger (hardware):

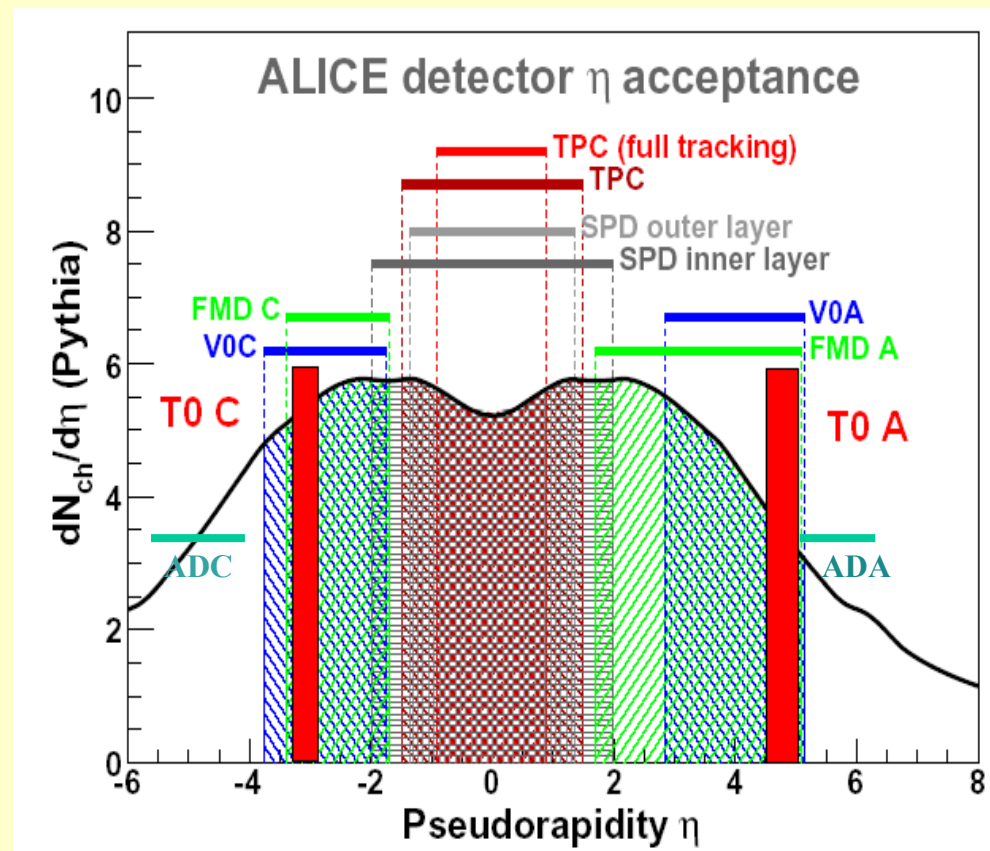
Pixel or TOF mult (central barrel)

V0A: gap η_+ : $2.8 < \eta < 5.1 \rightarrow \Delta\eta \sim 4 \times 0.6$

V0C: gap η_- : $-3.7 < \eta < -1.7 \rightarrow \Delta\eta \sim 4 \times 0.5$

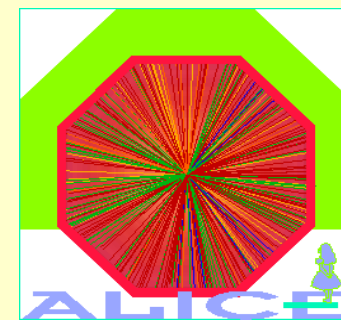
high level trigger (software):

gap η_+ : $0.9 < \eta < 5.1$ } V0-FMD-
 gap η_- : $-3.7 < \eta < -0.9$ } SPD-TPC



→ *improved including ADA, ADD*

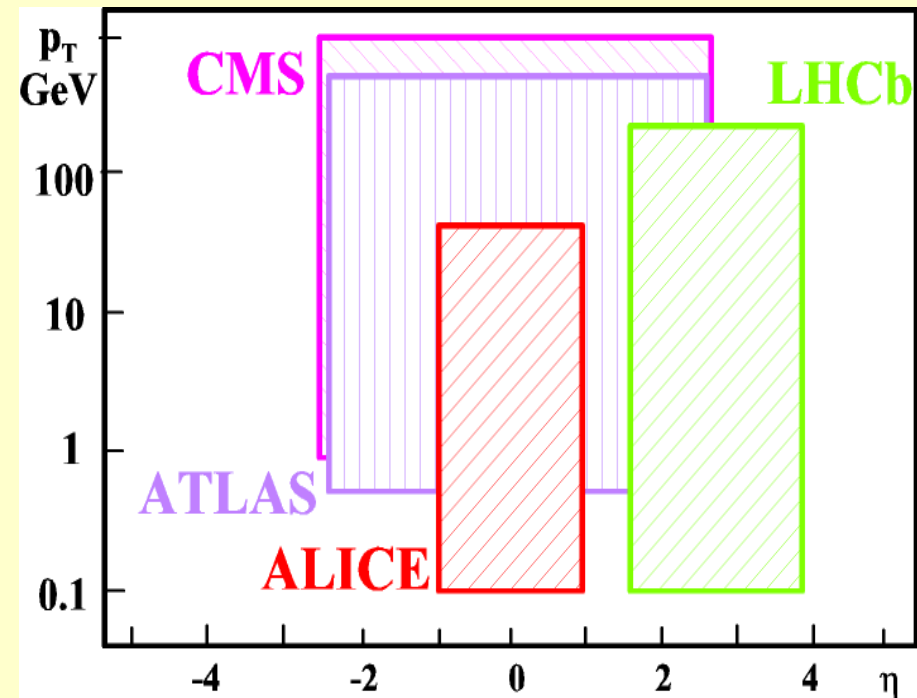
ALICE central barrel comparison to other LHC detectors



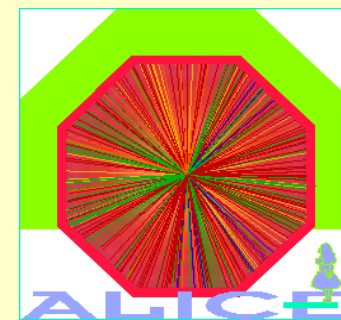
low magnetic field

	Magn. field (T)	P_T cutoff GeV/c	Material x/x_0 (%)
ALICE	0.2-0.5	0.1-0.25	7
ATLAS	2.0	0.5 (0.08)	20
CMS	4.0	0.75 (0.2)	30
LHCb	4Tm	0.1	3.2

η - p_T acceptance



→ low p_T trigger ?



ALICE acceptance

- ALICE acceptance matched to diffractive central production:

central

C-side *barrel* *A-side*
 $\Delta\eta \sim 3$ $\Delta\eta \sim 2$ $\Delta\eta \sim 4$

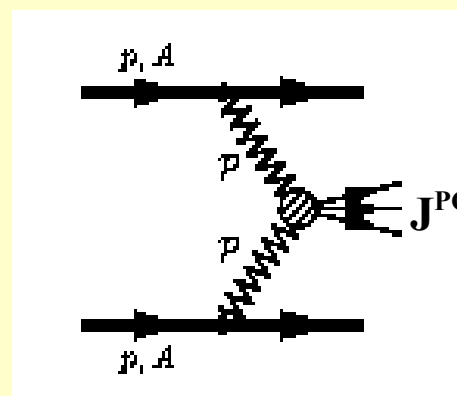
gap	had	gap
-----	-----	-----

Activity table

yes	yes	no
no	yes	no
no	yes	yes
yes	yes	yes

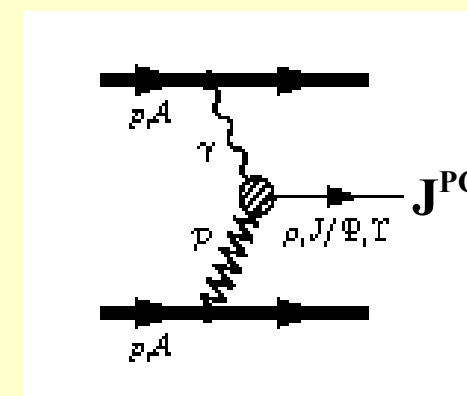
gap A
double gap
gap C
no gap

double pomeron



$L=0: J^{PC}=0^{++}$
 $L=1: J^{PC}=1^{-+}$

γ -pomeron

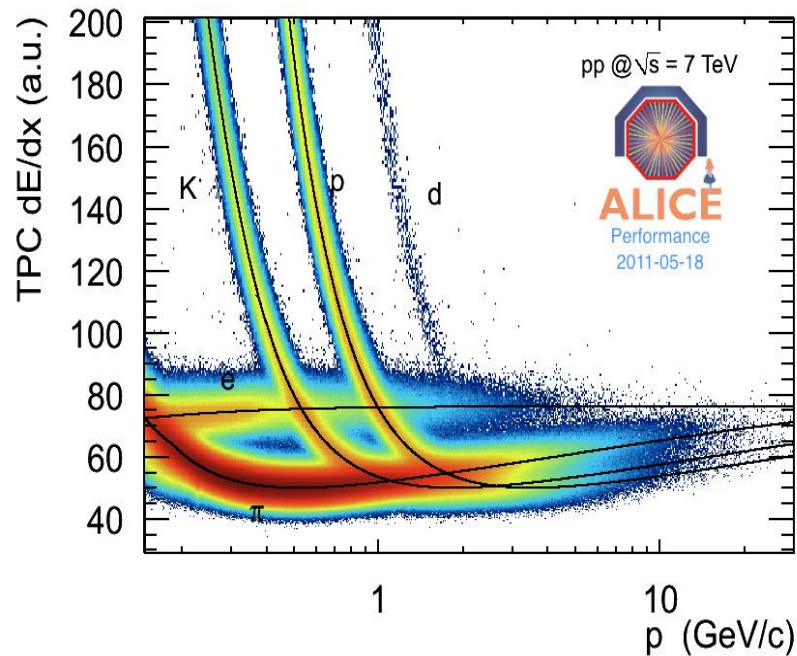
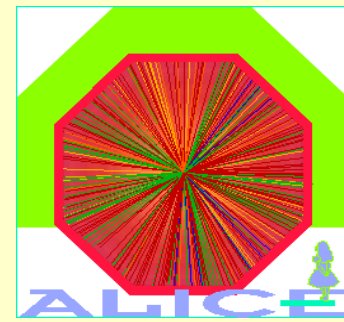


$L=0: J^{PC}=1^{-}$
 $L=1: J^{PC}=0^{+}, 1^{+}, 2^{+}$

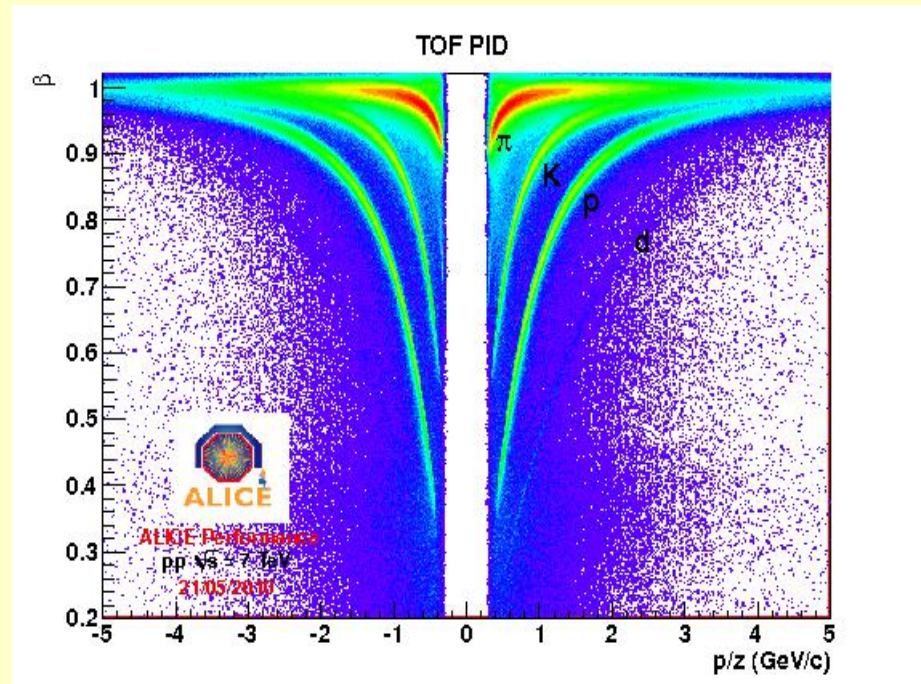
Data taking at design luminosities:
pp @ $L = 5 \times 10^{30} \text{ cm}^{-2}\text{s}$
p-Pb @ $L = 10^{29} \text{ cm}^{-2}\text{s}^{-1}$
Pb-Pb @ $L = 10^{27} \text{ cm}^{-2}\text{s}^{-1}$

($\rightarrow \frac{d\sigma}{dy}|_{y=0} \sim nb$)

Particle Identification in ALICE

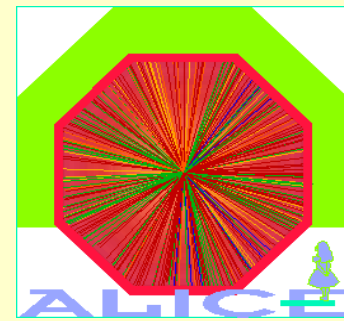


TPC dedx spectrum in pp-collisions at $\sqrt{s} = 7$ TeV



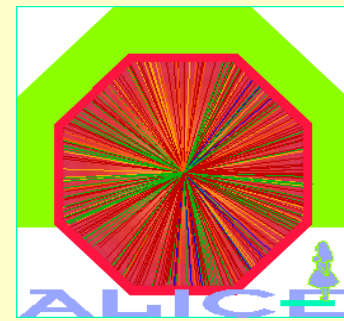
TOF measured particle beta vs. signed momentum in pp-collisions at $\sqrt{s} = 7$ TeV

Central Meson production in pp-collisions at $\sqrt{s} = 7$ TeV

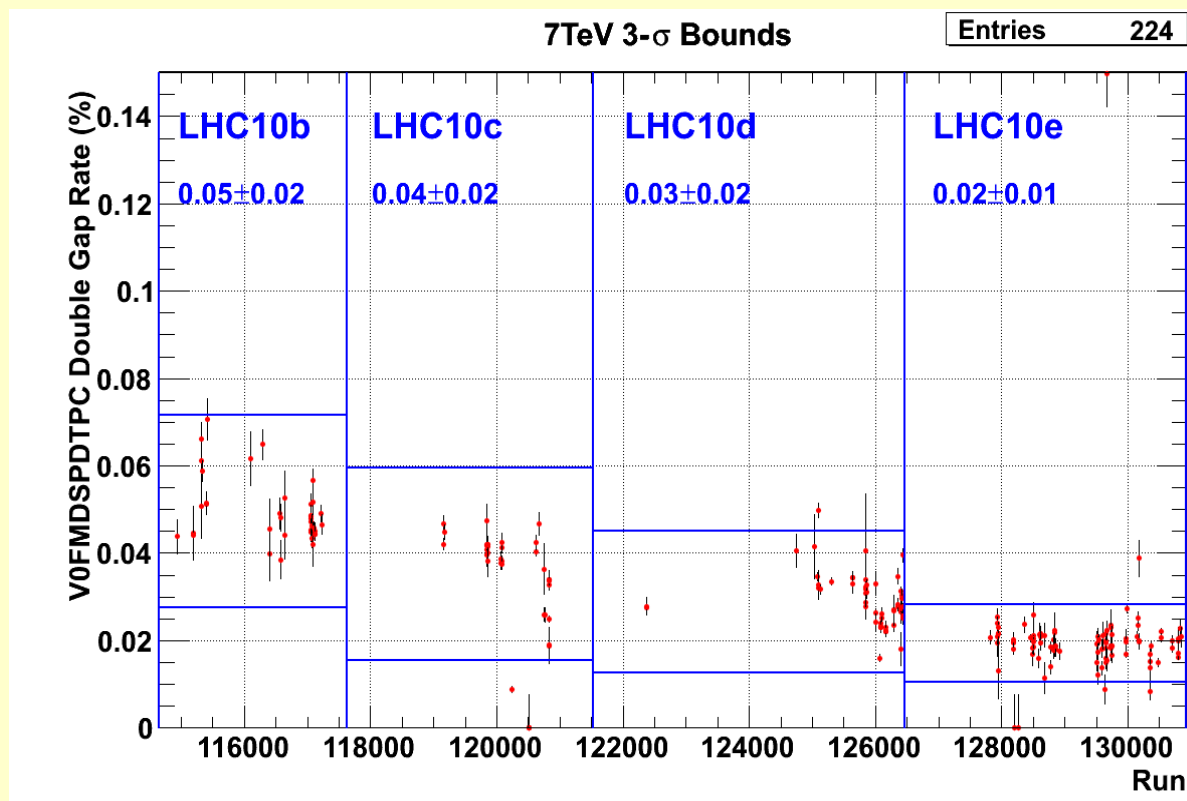


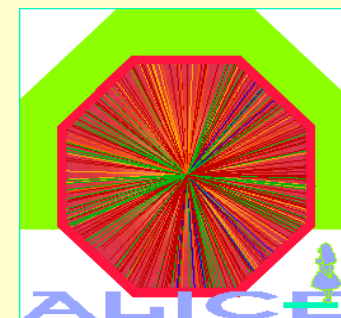
- Data taken in 2010-2011 with minimum bias trigger
- Offline analysis event type: no gap/gap A/gap C/double gap
- Compare single/double gap events to no gap events
- Analysis of multiplicity-distribution
- Analysis of $f_0(980)$ and $f_2(1270)$ production

First analysis min bias data



3 σ cut on single gap, double gap fraction on a run basis

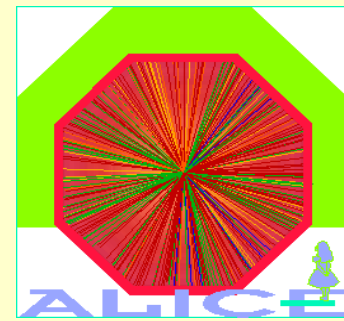




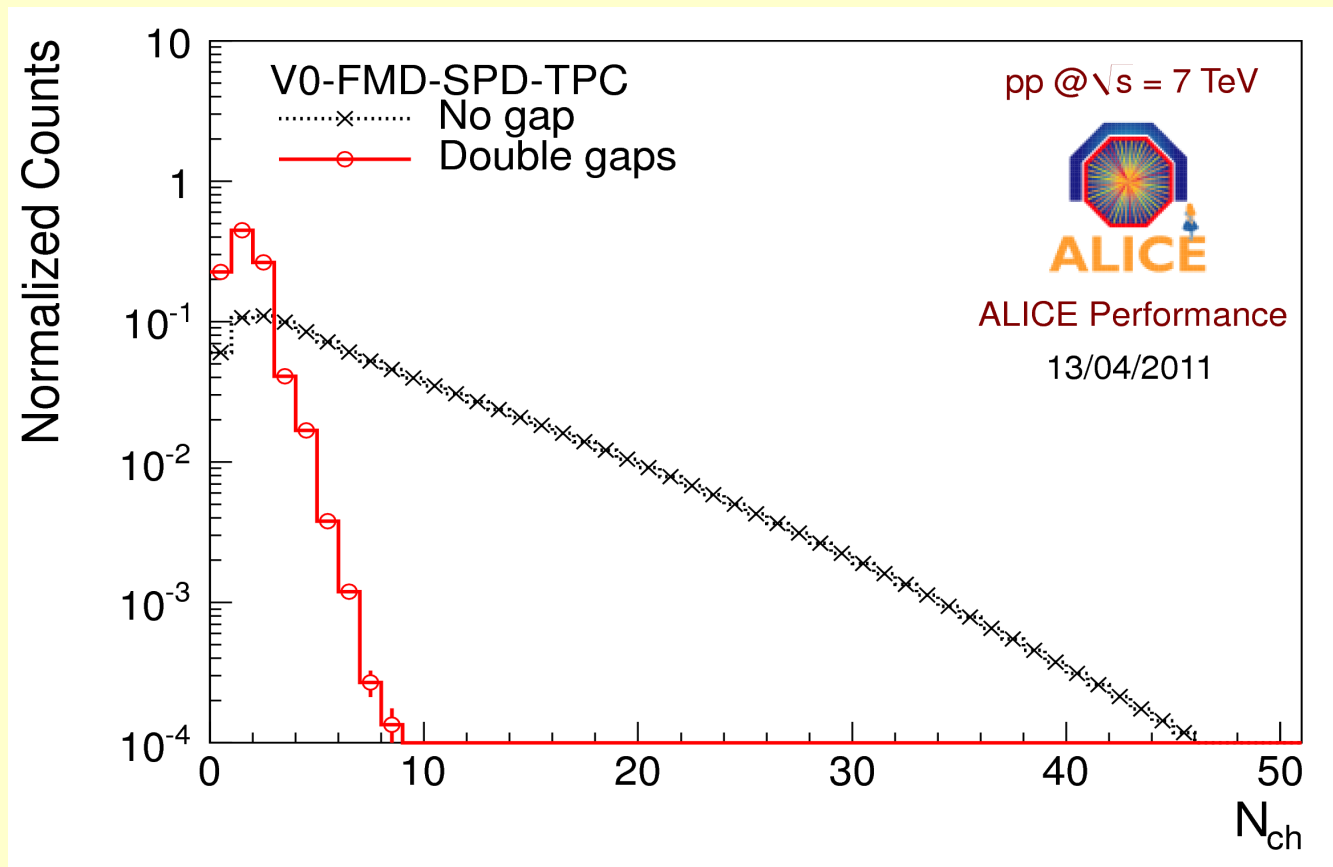
Data sample pp collisions at $\sqrt{s} = 7$ TeV

- Cuts on beam-gas events and background 3.5×10^8
- Primary vertex 2.9×10^8
- 2-track events total 3.2×10^7
 - no gap 3.1×10^7
 - double gap V0 (L0 trigger) 1.6×10^5
 - double gap V0-FMD-SPD-TPC 2.2×10^4

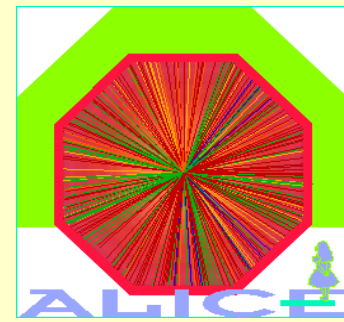
Multiplicity distribution



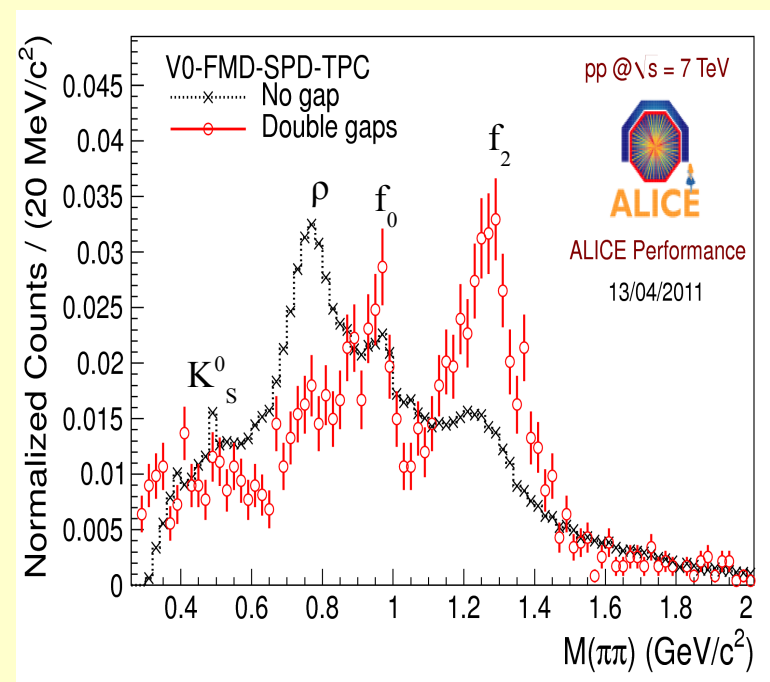
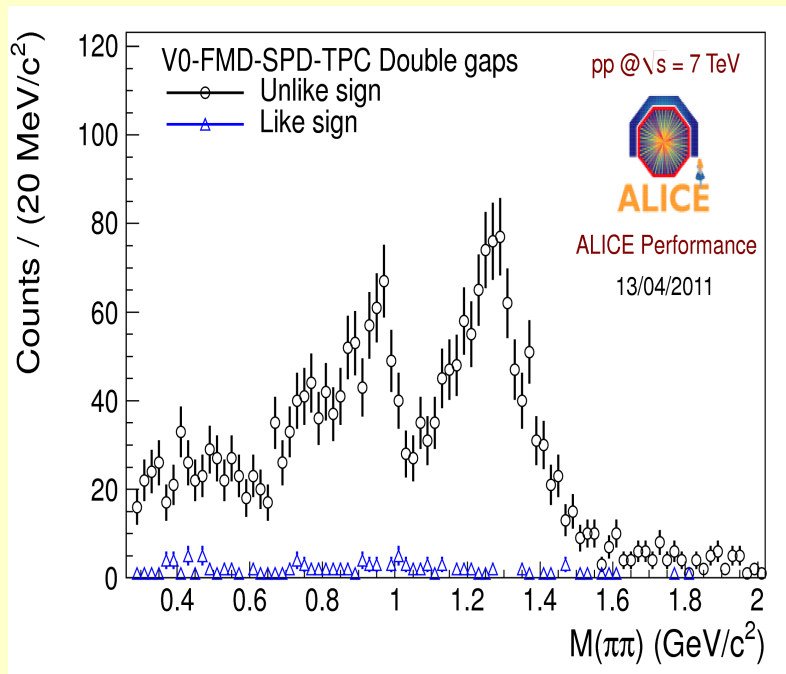
- Multiplicity distribution of gap and no gap events (good tracks)



Invariant mass distribution



- Invariant mass distribution of pion pairs

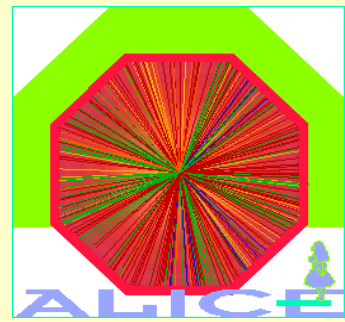


distribution for double gap events
unlike and like-sign pairs
(not corrected for
 p_T -dependent acceptance)

like-sign corrected distribution for
double and no-gap events

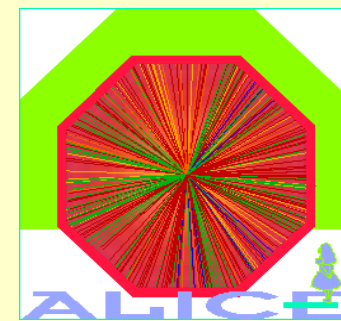
→ enhanced f_0, f_2 production in double gap events

Diffraction data taking in Pb-Pb- collisions at $\sqrt{s}_{NN} = 2.76$ TeV



- Heavy-ion collisions Pb-Pb at the LHC nov-dec 2010
- ALICE collected data on 12 M minimum bias collisions
- dedicated diffractive triggers running:
 - OM2 – TOF only trigger: (number of hits in TOF ≥ 2)
 - CCUP2 – TOF+SPD+V0 trigger: (TOF hits ≥ 2) AND (SPD hits ≥ 2) AND (V0A, V0C)
 - CMUP1 – Muon arm + V0 trigger: (at least one muon candidate) AND (V0A)
- OM2 running in early low luminosity runs, CMUP1 and CCUP2 in later parts, CCUP2 downscaled by factor 5-30

Electromagnetic/diffractive interactions in heavy ion collisions at high energies



- Electromagnetic interactions in heavy ion reactions:
 - Photoabsorption with breakup of nucleus or excitation of giant dipole resonance followed by neutron emission → beam particle is lost
 - Photon-photon: Electromagnetic production of pseudoscalars π^0, η, η' and pairs of bosons ($\pi^+\pi^-, K^+K^-$) and fermions ($e^+e^-, \mu^+\mu^-, \tau^+\tau^-$)
 - Photon-hadron: diffractive photoproduction of vector mesons

Baur et al, *Coherent gamma-gamma and gamma-A interactions in very peripheral collisions at relativistic ion colliders*, Phys. Rep. **364**, 359 (2002)

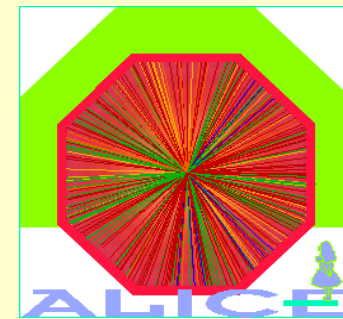
	AA→X nuclear	AA→AAX PP → hadrons	AA→AAX $\gamma\gamma \rightarrow$ hadrons	AA→AAX $\gamma P \rightarrow$ hadrons
$\sigma(pp)$ @LHC	70 mb	0.52 mb	15 nb	2.8 μ b
$\sigma(PbPb)$ @LHC	7.8 b	0.84 mb	150 mb	11 mb

$M_{\text{hadr}} > 1 \text{ GeV}$

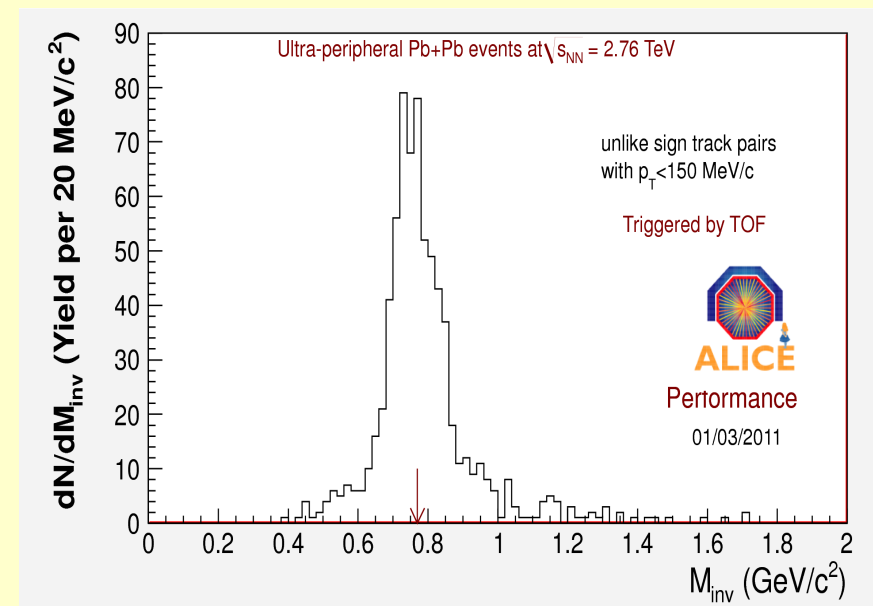
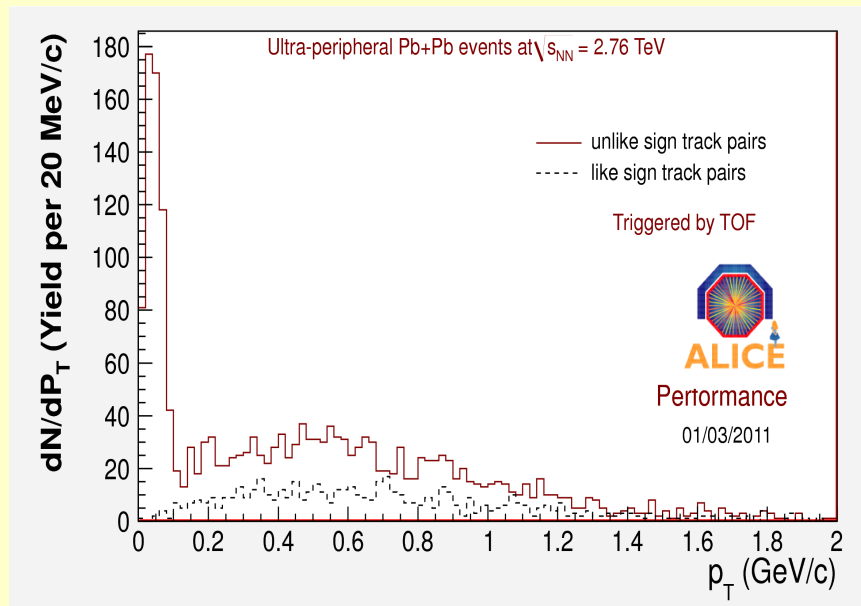
PbPb: $\gamma P \rightarrow$ hadrons: Excl. photoprod. $\rho \rightarrow \pi^+\pi^-$

Starlight MC: $\sigma = 3.9 \text{ b}$, Frankfurt, Zhalov, Strikman: $\sigma = 7.1 \text{ b}$

Central Meson production in Pb-Pb collisions at $\sqrt{s}_{NN} = 2.76$ TeV



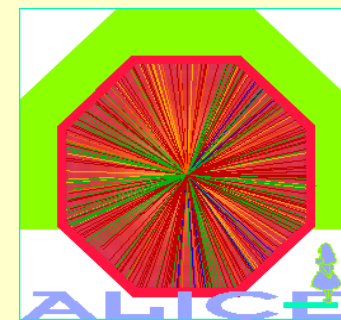
- Events triggered by OM2 (TOF only) which contain two reconstructed tracks
 → *coherent production implies low transverse momentum $p_T < \sim 100$ MeV/c*



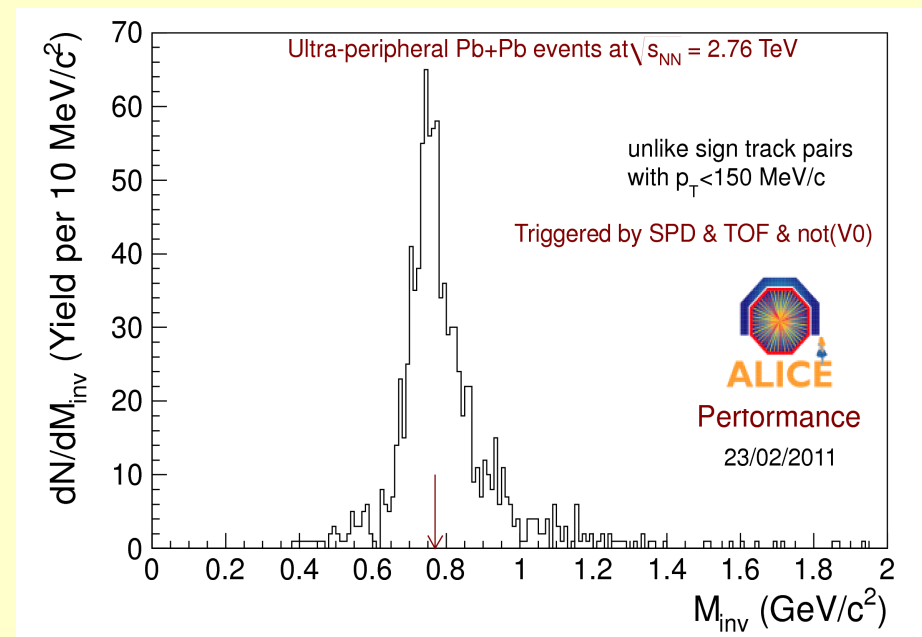
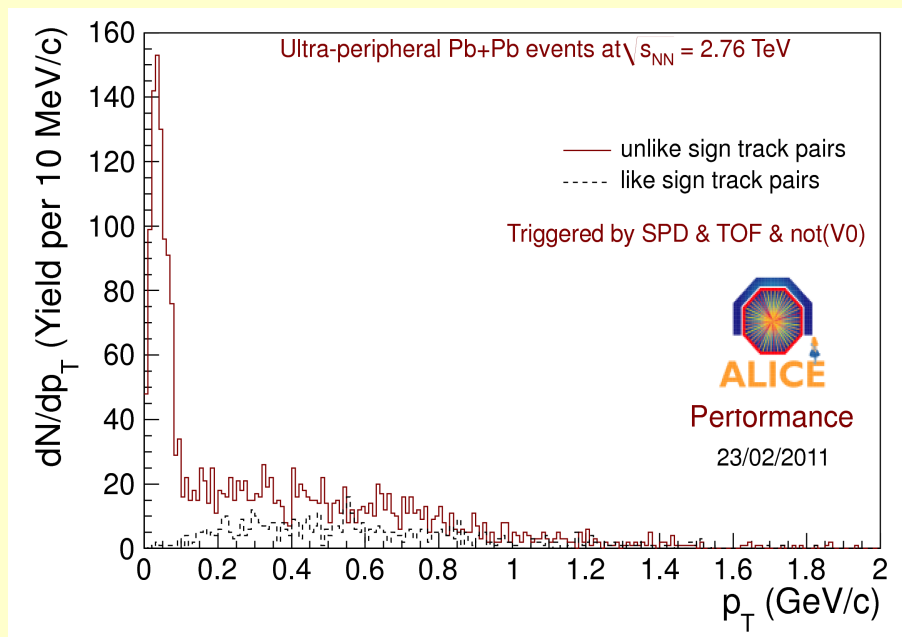
Pair p_T for unlike and like-sign pairs
 → *Coherent peak seen in unlike-sign pairs, not seen in like-sign pairs*

Uncorrected M_{inv} distribution of unlike-sign pairs with $p_T < 150$ MeV/c
 → *Coherent ρ -production*

Central Meson production in Pb-Pb-collisions at $\sqrt{s_{NN}} = 2.76$ TeV



- Events triggered by CCUP2: (activity in central barrel) AND $(\overline{V0A}, \overline{V0C})$



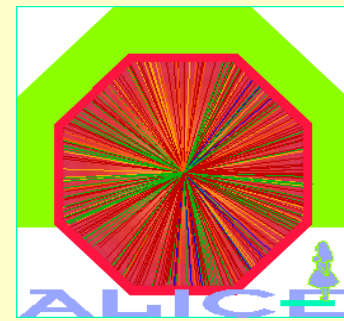
Pair p_T for unlike and like-sign pairs

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Uncorrected M_{inv} distribution of unlike-sign pairs with $p_T < 150$ MeV/c

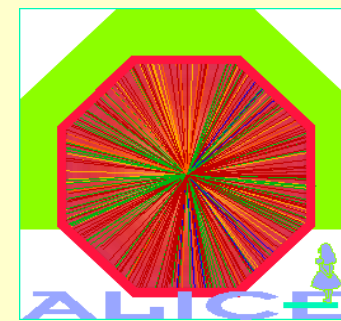
→ *Coherent ρ -production*

Conclusions, outlook

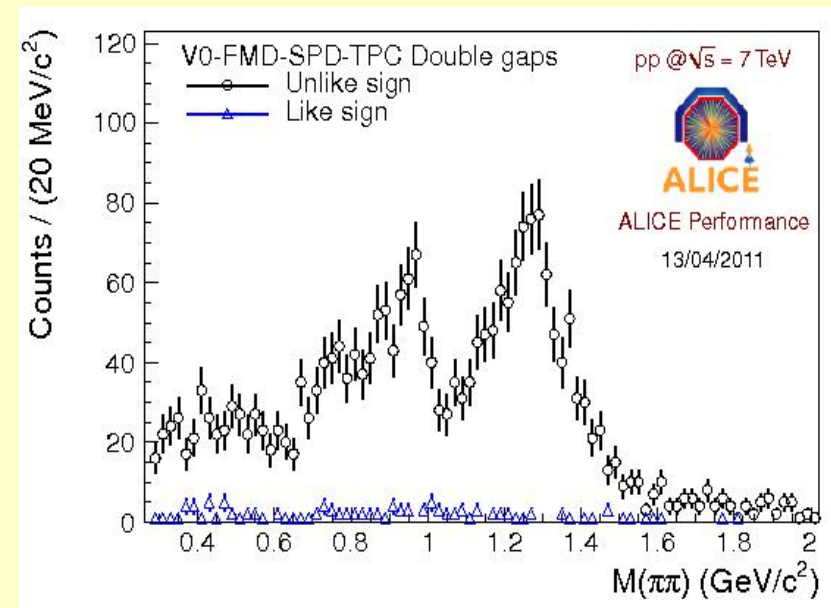
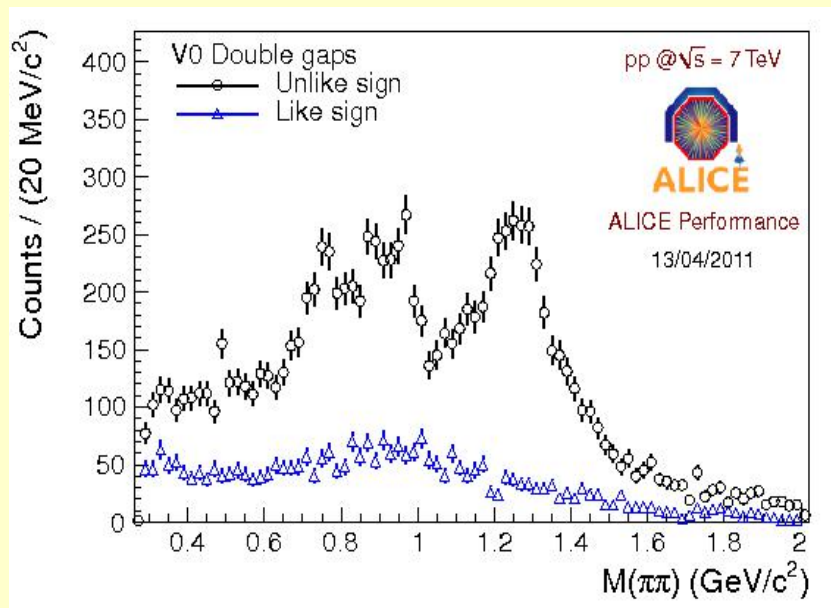


- Double gap selects different diffractive channels in pp and Pb-Pb collisions
- Pomeron-Pomeron in pp-collisions:
 - Double gap events show different multiplicity distribution
 - Two track invariant mass distribution of double gap events can be understood as continuum plus f_0 , f_2 resonance contribution
 - f_0 , f_2 enhancement in double gap events as compared to no-gap events
- Photon-Pomeron in Pb-Pb-collisions:
 - Coherent ρ -photoproduction established as dominant reaction channel in double gap events of Pb-Pb-collisions
 - ρ -photoproduction cross section to be determined
 - Search $J/\psi \rightarrow e^+e^-$, $\gamma\gamma \rightarrow e^+e^-$ in central barrel, $J/\psi \rightarrow \mu^+\mu^-$, $\gamma\gamma \rightarrow \mu^+\mu^-$ in muon arm
- Add Zero Degree Calorimeter info to study breakup/no breakup of beam particles

Backup: Gap definition in ALICE



Invariant mass of pion pairs in double gap events



gap definition:

V0A: $2.8 < \eta < 5.1$

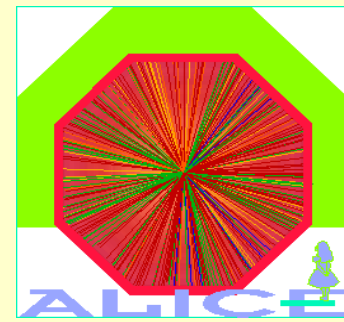
V0C: $-3.7 < \eta < -1.7$

gap definition:

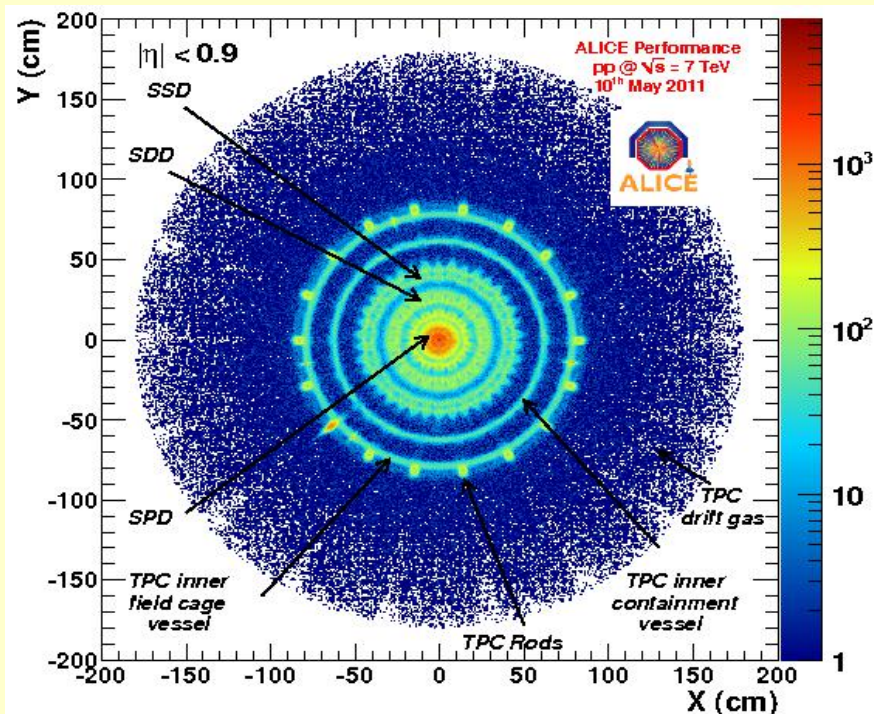
V0A-FMD-SPD-TPC: $0.9 < \eta < 5.1$

V0C-FMD-SPD-TPC: $-3.7 < \eta < -0.9$

Backup: Photon measurements in ALICE



- Photon measurements in ALICE by EMCAL, PHOS and conversion method



X vs Y distribution of reconstructed photon conversions

Two electromagnetic calorimeters:

EMCAL: $-0.7 < \eta < 0.7$, $\Delta\phi = 110^\circ$
lead sampling, WS-fiber readout

PHOS: $-0.12 < \eta < 0.12$, $\Delta\phi = 100^\circ$
 PbWO_4 crystals, PIN-diode readout